Issued September 13, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF CHEMISTRY—BULLETIN No. 158.

R. E. DOOLITTLE, Acting Chief of Bureau.

A BACTERIOLOGICAL STUDY OF SHELL, FROZEN, AND DESICCATED EGGS;

MADE UNDER LABORATORY CONDITIONS AT WASHINGTON, D. C.

BY

GEORGE WHITFIELD STILES, Jr.,
Bacteriological Chemist,

AND

CARLETON BATES,
Assistant Bacteriologist.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

ORGANIZATION OF BUREAU OF CHEMISTRY.

R. E. DOOLITTLE, *Acting Chief of Bureau.*
F. L. DUNLAP, *Associate Chemist.*
W. D. BIGELOW, *Assistant Chief of Bureau.*
F. B. LINTON, *Chief Clerk.*
J. G. SHIBLEY, *Supervisory Clerk, Interstate and Import Records.*
G. O. SAVAGE, *Editor.*
A. E. DRAPER, *Librarian.*

Division of Foods, W. D. BIGELOW, *Chief.*
Food Inspection Laboratory, L. M. TOLMAN, *Chief.*
Food Technology Laboratory, E. M. CHACE, *Chief, and Assistant Chief of Division.*
Oil, Fat, and Wax Laboratory, H. S. BAILEY, *Chief.*

Division of Drugs, L. F. KEBLER, *Chief.*
Drug Inspection Laboratory, G. W. HOOVER, *Chief.*
Synthetic Products Laboratory, W. O. EMERY, *Chief.*
Essential Oils Laboratory, E. K. NELSON, *Chief.*
Pharmacological Laboratory, WILLIAM SALANT, *Chief.*

Chief Food and Drug Inspector, W. G. CAMPBELL.

Miscellaneous Division, J. K. HAYWOOD, *Chief.*
Water Laboratory, W. W. SKINNER, *Chief.*
Cattle-Food and Grain Laboratory, G. L. BIDWELL, *Acting.*
Insecticide and Fungicide Laboratory, C. C. McDONNELL, *Chief.*
Trade Wastes Laboratory, *under Chief of Division.*

Contracts Laboratory, P. H. WALKER, *Chief.*

Dairy Laboratory, G. E. PATRICK, *Chief.*

Food Research Laboratory, M. E. PENNINGTON, *Chief.*

Leather and Paper Laboratory, F. P. VEITCH, *Chief.*

Microchemical Laboratory, B. J. HOWARD, *Chief.*

Physical Chemistry Laboratory, C. S. HUDSON, *Chief.*

Sugar Laboratory, A. H. BRYAN, *Chief.*

Sections:
Animal Physiological Chemistry, F. C. WEBER, *in Charge.*
Bacteriological Chemistry, G. W. STILES, *in Charge.*
Enological Chemistry, W. B. ALWOOD, *in Charge.*
Nitrogen, T. C. TRESCOT, *in Charge.*
Plant Physiological Chemistry, J. A. LECLERC, *Chief.*
Food Technologist, A. W. BITTING.

Food and Drug Inspection Laboratories:
Boston, B. H. SMITH, *Chief.*
Buffalo, W. L. DUBOIS, *Chief.*
Chicago, A. L. WINTON, *Chief.*
Cincinnati, B. R. HART, *Chief.*
Denver, R. S. HILTNER, *Chief.*
Detroit, H. L. SCHULZ, *Chief.*
Galveston, G. M. BARTLETT, *Acting.*
Honolulu, Hawaii, A. W. HANSEN, *Acting.*
Kansas City, Mo., F. W. LIEPSNER, *Chief.*
Nashville, R. W. BALCOM, *Chief.*
New Orleans, W. J. McGEE, *Chief.*
New York, A. W. OGDEN, *Acting.*
Omaha, S. H. ROSS, *Chief.*
Philadelphia, C. S. BRINTON, *Chief.*
Pittsburgh, M. C. ALBRECH, *Chief.*
Portland, Oreg., A. L. KNISELY, *Chief.*
St. Louis, D. B. BISBEE, *Chief.*
St. Paul, A. S. MITCHELL, *Chief.*
San Francisco, R. A. GOULD, *Chief.*
San Juan, P. R., A. E. TAYLOR, *Acting.*
Savannah, W. C. BURNET, *Chief.*
Seattle, H. M. LOOMIS, *Chief.*

Issued September 13, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF CHEMISTRY—BULLETIN No. 158.

R. E. DOOLITTLE, Acting Chief of Bureau.

A BACTERIOLOGICAL STUDY OF SHELL, FROZEN, AND DESICCATED EGGS;

MADE UNDER LABORATORY CONDITIONS AT WASHINGTON, D. C.

BY

GEORGE WHITFIELD STILES, Jr.,
Bacteriological Chemist,

AND

CARLETON BATES,
Assistant Bacteriologist.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., March 11, 1912.

Sir: I have the honor to transmit for your approval the results of a study made by the bacteriological chemist of this bureau and his assistant of fresh eggs of known quality in the shell, and of frozen and desiccated eggs prepared from different grades of materials and under commercial and laboratory conditions, in Washington, D. C. It is thought that these data will be of special interest and profit to those manufacturing these products, in their endeavors to produce a more acceptable foodstuff, as well as to the bakers, confectioners, etc., by whom they are largely purchased. The eggs examined in this work were purchased either direct from the producers or in the open market and were intended for direct consumption. The data obtained are therefore of additional interest as compared with those secured at the factories where eggs are prepared for preservation, which problem is now being studied in an independent research conducted by this Bureau in collaboration with the Bureau of Animal Industry.

I recommend that the manuscript be published as Bulletin 158 of the Bureau of Chemistry.

Respectfully,

H. W. Wiley,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
Conditions affecting the quality of eggs used for freezing and drying	9
Grading of eggs	11
Breaking and mixing eggs	13
Methods of drying eggs	14
Instantaneous method	14
Belt method	14
Disk method	15
Tray or board method	15
General sanitary precautions	16
Factory location and construction	16
Air filtration for desiccation	17
Cleansing and sterilizing utensils	17
Methods used in the bacteriological examination of eggs	18
Sterilization	18
Culture media	18
Sampling	18
Records	18
Technique of examination	18
Plating cultures	19
Fermentation tests	19
Anaerobic cultures	19
Incubation	20
Counting colonies	20
B. coli determinations	20
Streptococci determinations	20
Other organisms	20
Bacteriological data on fresh eggs	21
Procedure	21
Detailed data obtained	21
Summary of results on fresh eggs	24
Experiments with frozen egg products	24
Preparation of samples	24
Bacteriological data	25
Summary of results on frozen egg products	29
Experiments with dried egg products	31
Conditions of the experiment	31
Bacteriological data	32
Summary of results on dried egg products	34
General conclusions	34

ILLUSTRATIONS.

PLATES.

		Page.
Plate I.	Fig. 1.—A good storage egg, showing whole yolk surrounded by transparent white. Fig. 2.—Weak egg, showing the flowing yolk	16
II.	Fig. 1.—Rotten egg, showing disintegration of yolk. Fig. 2.—Spot egg, showing the development of an embryo chick	16
III.	Desiccated egg products	16

TEXT FIGURES.

Fig. 1.	—Graph showing bacterial content of frozen eggs of known grades, examined at intervals, and averaged by months	30
2.	—Graph showing bacterial content of desiccated eggs of known grades, examined at intervals, and averaged by months	35

A BACTERIOLOGICAL STUDY OF SHELL, FROZEN, AND DESICCATED EGGS.

INTRODUCTION.

The production of the necessary quantity of food of such wholesomeness as to nourish properly the ninety or more million people who inhabit this country is a complex problem and one which will require more thought and consideration as the population continues to increase. Generally speaking, when food products are produced in large quantities remote from ready markets, the selling price of such commodities at the point of production is usually far below that obtained for the same material when sold in large cities even though the quality of the goods may have deteriorated from age and careless handling.

According to the demand and the difficulties attending the shipment and handling of perishable food products, the competition between middle men often becomes very keen, and too frequently inferior articles of food find their way to the consumer under the misleading label "strictly fresh" when as a matter of fact they are not fresh and should not be so designated.

The difficulty in securing eggs of a known history for food purposes is known to every housewife and purchaser of food materials. When eggs are bought in the shell by the consumer, and are broken under his supervision, it is possible to distinguish and separate the reasonably good eggs from the undoubtedly bad, and discard the objectionable ones if so desired. On the other hand, when eggs are purchased by commercial firms for purposes of freezing and drying, the individual egg in the shell loses its identity when broken and mixed with other eggs to be frozen or dried. Should partially decomposed eggs, or certain kinds of "rots" and "spots," be added to a mixture of such products, there is no method of separating the inferior and objectionable parts from the good material. Therefore, exceedingly great care should be exercised in manufacturing frozen and dried eggs intended for human consumption.

These products are largely used for cooking purposes where inferiority is concealed, as in baking cakes or making custards, omelets, pies, etc.; thus it becomes the duty of health officials to exercise very

strict supervision over the quality of eggs entering into such combinations. Eggs and other albuminous food substances in which decomposition has begun do not necessarily have a fetid odor or a changed appearance, taste, or consistency, but may be dangerous because of the toxins formed from bacterial activity.[1] The odor particularly is masked in a dried or frozen product. Again, the process of baking dissipates the odor of stale eggs in such a manner that the finished cake or custard when cold is free from the objectionable odor, which may have been present when it was removed hot from the oven.

The traffic in eggs sold for drying and freezing has greatly increased during the past few years. Strictly fresh marketable eggs in the shell command a high price and there is difficulty in meeting the demand for such products, but large quantities of questionable eggs, often bought at very low prices, have been broken out for cooking purposes by disreputable firms, being preserved by freezing or drying until ready for use. Some dealers, however, manufacture a satisfactory product by the use of good eggs handled under proper conditions. Strictly fresh eggs with sound, clean shells, always bring the highest price in the shell, and no subsequent treatment by freezing or drying will increase their market value or enhance their desirability as a food.

There are two general methods employed for preserving eggs when removed from their shells. One depends on the application of low temperature (0° F. to 10° F.) furnishing the frozen article; while in the dried or desiccated product preservation is largely accomplished by abstracting water from the broken eggs, the finished goods containing from 3 to 8 per cent of moisture. The application of these methods of preserving various food products is recognized as a perfectly legitimate business, but no amount of freezing or drying will rejuvenate partly decomposed foods or restore them to their former condition. The low quality of food products is too frequently attributed to cold storage, whereas, in reality, such materials were either in bad condition before being placed in storage or became so from delayed or insanitary handling subsequent to removal from storage. The use of low temperatures and the abstraction of moisture from organic material simply retard further decomposition and decay for a reasonable length of time, the period varying according to the character of the product and the manner of handling.

There is no objection to drying or freezing good eggs under proper sanitary conditions; in fact, there are some advantages to be gained by preserving eggs in this manner, although the manufacturing processes devised by man, as a rule, do not improve the quality of nature's work. Conditions of modern life and commerce must, how-

[1] Dieudonné. Bacterial Food Poisoning, translated by Dr. C. F. Bolduan. New York, N. Y., 1909.

ever, be met, and dried eggs or eggs in a frozen condition may be shipped long distances, and require less space for transportation and storage than do eggs in the shell.

During the past three years there have been examined bacteriologically in the Bureau of Chemistry hundreds of samples of frozen and desiccated eggs collected from shipments entering into interstate commerce. In many instances the bacterial content of these products was exceedingly high, and a large proportion of the total bacterial content represented fecal organisms of the *B. coli* and *streptococci* groups; thus indicating, in the language of the food law (sec. 7), that the product is adulterated, since "it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance."

The object of this report is to present briefly the data obtained during these investigations and to offer a few suggestions to the trade which may be of value in correcting some of the existing practices and conditions which are at least partially responsible for the unsatisfactory products now found on the markets.

CONDITIONS AFFECTING THE QUALITY OF EGGS USED FOR FREEZING AND DRYING.

The majority of the large egg-breaking establishments are located within a few hundred miles of their source of supply. In such instances the goods handled usually represent a better grade of material than that obtained as a by-product from the trade in larger cities more remote from centers of handling, where environment, temperature, season of the year, etc., would materially affect the quality of the finished product.

A large proportion of the eggs used for freezing and drying are purchased on the "case count" basis.[1] These eggs may be received at the factory direct from the farmers or producers; in a large percentage of cases, however, the eggs used are first sold in small lots by the farmer to the village grocer.[2] They may be marketed weekly or more frequently, according to the convenience of either merchant or producer. After a certain time, varying according to the supply and demand and convenience of the merchant, the eggs fall into the hands of commission agents, who endeavor to dispose of their wares to the best advantage. In most instances the "firsts," or the best eggs from such consignments, are sold in the shell and are not offered to egg-breaking establishments because of prohibitive prices.

During the shipment of eggs in carload lots there is usually a certain percentage damaged from rough handling, constituting grades

[1] Hastings. The Egg Trade of the United States. U. S. Dept. Agr., Bureau of Animal Industry Cir. 140.

[2] Indiana Agr. Exper. Sta., Newspaper Bul. No. 177, Apr. 29, 1911, "Improve Indiana Egg Conditions."

known as "checks," "cracks," and "leakers."[1] These eggs, with the exception of the leakers, may be perfectly wholesome for food, and would make a satisfactory product if broken at once and preserved under satisfactory conditions. At times the necessary care and attention to sanitary practices are not exercised in breaking such eggs, the results often showing a highly contaminated article.

It is the custom in certain cities for some of the less scrupulous egg-breaking dealers to secure a portion of their material for breaking by collecting small lots from various commission merchants. These segregated lots, some of which cost little if anything, are broken and mixed with eggs received from other sources and either are sold direct to the baking trade before freezing or are preserved for future demands. The prices paid for eggs used strictly for breaking purposes fluctuate greatly. They generally bring less than one-third of the prevailing price for the highest grades. The lowest prices reported paid by any one firm was 50 cents per case of 30 dozen. This firm dealt in eggs intended for tanning purposes as well as for human consumption. The usual price paid is higher than this, varying from $1.50 to $6 a case of 30 dozen, or from 5 to 20 cents a dozen.

The egg-breaking season is from about April 1 to October 1, varying according to locality and season, the bulk of the business being carried on in June and July, during the warmest months of the season. Eggs laid in summer are less desirable for storage than those laid in April or May, which "hold up" far better than the weaker or thinner eggs produced near the end of the laying season.[2] Warm weather naturally contributes to more rapid spoilage and decay, and other conditions make contamination more probable during this season of the year than during the colder months.

The primary responsibility for a wholesome egg supply undoubtedly rests with the producer. It is only too true that a large percentage of inferior eggs are marketed directly from the farms to local buyers, but a certain number of eggs become injured and deteriorate during shipment, storage, and subsequent handling.[3] The age of the egg, sanitary environment during its entire history, and climatic conditions are factors which largely govern quality at the time of marketing.

Certain undesirable practices attending the production of shell eggs have been recognized for a long time, and vigorous steps are now being taken by the Federal Government and some of the States,

---

[1] Pennington, M. E., and Pierce, H. C. Effect of the Present Method of Handling Eggs. U. S. Dept. Agr. Yearbook, 1910, pp. 469–470; U. S. Dept. Agr., Bureau of Animal Industry Bul. 141.

[2] Pennington, M. E. Poultry from the Farm to the Consumer. U. S. Dept. Agr., Bureau of Chemistry Cir. 64, p. 36.

[3] U. S. Dept. Agr., Yearbook, 1910. Pennington and Pierce, loc. cit.; Farmers' Bul. 445, Marketing eggs through the creamery, by R. R. Slocum; Bureau of Animal Industry Bul. 141.

particularly Kansas, Oklahoma, Nebraska, Indiana, Minnesota, Michigan, and Missouri, to do away with these unsatisfactory conditions. Considerable progress has been made, but much yet remains to be done. The introduction of the "loss-off" basis as applied to buying eggs is a step in advance over the method of purchasing them by "case count."

Producers of eggs should give more careful attention to the details of this extremely profitable industry. According to the statistics for 1907,[1] the poultry and egg business of the country was estimated at $600,000,000, and the average price paid for eggs in the United States was 18.2 cents per dozen. In 1909 the average price was 19.7 cents.[2]

Eggs should be produced from healthy hens under cleanly conditions and kept at low temperatures until consumed. They should be marketed twice or thrice weekly, and eggs of doubtful quality should be carefully sorted before selling.[3] Shell eggs produced and sold under good conditions are worth more than the carelessly produced article, and they command a selling price sufficiently in advance of the average grade to repay the farmer for the care and expense necessary to produce a better product.

GRADING OF EGGS.[4]

The grading of eggs is more difficult than that of most food products. Each egg must be considered as an individual unit, and the condition of the egg substance can not be accurately determined without first breaking the surrounding shell. In practice, eggs intended for sale in the shell are graded by observing their external appearance and by the candling process.

Eggs are judged from their external appearance according to size, form, color, cleanliness of the shell, and freedom from checks and cracks. All of these factors aid in passing upon the value and probable quality of the product. Internally, eggs in the shell are examined by candling, which is done by exposing each egg to a strong light inclosed within a suitable case in a darkened room. The operator holds the egg before a small opening in the case inclosing the light and by a series of quick turns brings all sides of the egg into view. After long experience the skilled operator is able to judge with fair accuracy the quality of the eggs, although a certain percentage of inferior eggs escapes the most expert candler. This is

---

[1] U. S. Dept. Agr., Yearbook, 1907, p. 20.

[2] Ibid., p. 589 (calculated).

[3] U. S. Dept. Agr., Bureau of Animal Industry Bul. 141.

[4] Information relative to the grading, classification, breaking, drying, and freezing of eggs and the trade practices were largely obtained by Carleton Bates and E. A. Read, of the Bureau of Chemistry, during a joint inspection tour among nearly 50 egg breaking and drying establishments. Work on grading eggs was also done in Washington at the microchemical and bacteriological laboratories.

especially true of "musty" and "sour" eggs, which cause some of the difficulties experienced in the trade.

It is in summer, during the egg-breaking season, that the largest percentage of inferior eggs escapes the candlers. Should they pass the breakers also, to be manufactured into frozen or dried egg products, they become a portion of the finished article. "Black rots" and large "blood rings," the more advanced types of spot eggs, are usually distinguished without difficulty by candling, but certain kinds of spots may escape detection.

(1) *Firsts and extras.*—This grade includes all freshly laid, sound, whole, clean shell, medium, and good-sized eggs. The best eggs of the year are laid during the spring months, and it is this grade which is usually selected for storage, to be removed some months later for the winter trade. The extras are selected from this grade to suit local demands of the city in which the eggs are to be sold. For example, a large, clean shell, whole, *brown* egg would be selected for markets in the vicinity of Boston, while on the other hand a large, clean shell, whole, *white* egg would be preferable for New York markets, the quality of the goods being the same in each case.

(2) *Seconds.*—Into this group enter all the grades not included under firsts, except the "spots" and "rots." This group may be further subdivided into others. Generally this grade contains all the under size, dirty, checked, cracked shell, or weak eggs, which could not be classed as firsts:

(*a*) Undersized: Eggs which may be classed as firsts except for their size.

(*b*) Checks and cracks: Eggs the shells of which have become broken by careless handling but which have intact shell membranes.

(*c*) Leakers: Eggs whose shells and shell membranes are sufficiently broken to permit a portion of their contents to escape.

(*d*) Dirties: Eggs the shells of which have become soiled from unclean nests, etc.

(*e*) Weak eggs: In this grade are placed all eggs in which the albumen has become weak or watery due to high or varying temperature changes.

All of the above-mentioned grades are considered to be suitable for food purposes when handled under proper conditions, except the leakers, which are generally badly contaminated.

(3) *Spots and rots.*—This grade comprises all of the discards and is considered useful only for manufacturing purposes, such as for tanning leather, etc.[1] They are eggs which show a spot before the candle. These spots may be due to developing embryos, blood rings, or molds, and the attachment of the yolk to the shell which may be caused by holding in one position.

[1] Rosenberger, Randle C. A study of eggs offered for sale as pure food. New York Medical Journal, 1910, *92* (27): 1313.

The illustrations of the individual eggs shown in Plates I and II were obtained by breaking eggs of known quality and grade into small watch glasses and photographing them with the camera in a vertical position. No illustration of the fresh egg is given, as the convexity of the sound firm yolk makes it difficult to secure the proper light to reproduce its characteristic appearance.

BREAKING AND MIXING EGGS.

The process of breaking eggs preparatory to drying or freezing is essentially the same. After grading, the eggs are sent to the breaking rooms, where they are usually broken by young girls, generally supervised by older and more experienced girls or forewomen. In certain factories the eggs are chilled previous to breaking, and they may be candled again after chilling.

The breaking process consists of removing the egg by breaking the shell in two, and if desired the yolks of sound eggs may be separated from the whites at this time. It is physically impossible to separate the albumen from the yolk of the eggs where there is any extensive blending of these two constituents. Eggs showing these marked changes usually contain large numbers of bacteria, indicating that decomposition has appreciably advanced. Such eggs would be discarded by the average housewife as being unfit for food, and can only be manufactured into mixed products containing the whole egg, in which inferiority would be concealed. Our examinations have shown that commercial mixed eggs, both the dried and the frozen, generally contain many more bacteria than do the commercial whites and yolks.

The shells of the eggs are broken over the sharp edge of a metal cup or knife blade, sometimes especially made for this purpose, after which the contents are placed in different vessels according to grade. The cups may contain from one to six eggs before they are emptied into larger receptacles. Theoretically, should an egg properly belonging to a lower grade enter a cup intended for that of a higher grade, the whole contents of the container are placed in the can corresponding in quality to the poorest grade egg in the cup. In practice this is not always done. Broken eggs are graded by their appearance, smell, and sometimes by their taste, the final grading of each being left largely to the judgment of the individual breaker. Should she be careless, or her sense of smell be impaired, eggs of inferior quality would probably escape her attention. In event of grave doubt as to the quality of a given egg, the forewoman or manager is called upon to act as referee. Should there still be doubt as to its quality the egg should be placed with the tanners' stock. It has been stated that an expert could break and grade 60 dozen eggs an hour, or 1 dozen a minute.

Having been broken, the eggs are usually strained through a colander, primarily for the purpose of breaking up the yolks and making a more homogeneous mass. The straining, if a small-meshed colander is used, would also remove developing embryos, masses of spots, etc., should they be present.

After straining, the eggs may be further blended by mixing in a churn or other specially constructed device used for this purpose. The mixed broken eggs are now ready to be frozen or dried. When a sharp freezer is not located on the premises they may be placed in a chilling room at 33° to 35° F., overnight, or if intended for drying, the liquid material conveyed at once to drying machines.

METHODS OF DRYING EGGS.

The normal, whole, hen's egg contains about 73.7 per cent of water.[1] During the drying process this amount is reduced to less than one-tenth of the original amount. It requires about 36 to 40 average-sized eggs to make 1 pound of dried material, representing three times the value of one dozen eggs in the shell.

There are four general methods used by the trade for drying eggs, though each manufacturer may vary the procedure slightly according to his desire and experience.

INSTANTANEOUS METHOD.

In many respects the instantaneous method is highly satisfactory from the sanitary point of view because of the quickness of drying. The high temperature used probably destroys or retards the development of the less resistant organisms present in the liquid material. The liquid eggs are sprayed into a heated chamber at a temperature of about 160° F., where they are immediately reduced to a fine powder which is carried on by currents of air through cotton bags or other filtering devices, on which it is retained and finally falls down into bins. The powdered product usually contains from 3 to 5 per cent of moisture, and is ready to be packed in suitable containers for sale.

BELT METHOD.

As suggested by the name, the belt method consists in drying the liquid egg on an endless belt, made of zinc or galvanized iron strips. The belts vary in length according to the size of the rooms and amount of output. The liquid egg may be held in vats and artificially refrigerated with circulating brine, or the feeding device of the drying machine may be equipped with brine pipes to keep the product cold. The liquid egg is applied to the revolving belt through a feeding device which permits a thin film to spread evenly over its surface.

[1] Leach, Albert E., Food Inspection and Analysis, 1909, p. 265.

This drying belt is inclosed within suitably constructed chambers into which heated filtered air is introduced. The temperature of the inclosed air surrounding the egg is about 140° F., and the time of drying can be largely governed by regulating the temperature of the air, the length of the belt, and the rate of its revolution. Each film of egg applied is usually dried in one complete revolution, and there are a large number of such films wound around the belt before separating the product from the drier. This is done by adjusting suitably-tipped metal scrapers in contact with the belt so as to remove the dried product, which then falls into drawers or bins. It requires from one and one-half to two hours to complete the first stage of the drying.

The product is next spread on wire screens and further dried by placing it in a "finisher," which is a large metal cabinet kept at 100° to 110° F. After remaining in the finisher two or three hours, the dried product is sifted and graded according to the size of the flake, or it may be ground to a uniform size or powdered. The finished product usually contains from 3 to 8 per cent of moisture. The goods are packed in suitable containers and placed in storage at low temperatures pending sale.

DISK METHOD.

The disk method consists of exposing the liquid egg in a vat to a series of large slate disks arranged on a slowly revolving shaft or axis. There are serious objections to this method as ordinarily practiced, since the egg is not fully protected from the outside air, and more frequent handling is necessary, thus subjecting it to greater exposure to contamination. Each drying requires several dippings, which are treated at about 100° F., the hot air being blown under the disks from the side. A much longer time is required to dry eggs by this method; the machine may be run all day and the material further dried at room temperature during the night, to be scraped off the following morning and subsequently treated like other dried-egg products.

TRAY OR BOARD METHOD.

The tray or board constitutes one of the simplest methods of drying and is perhaps the least satisfactory. Liquid eggs are spread by hand over boards or trays and placed on shelves in especially constructed cabinets. Hot air is forced through this cabinet, entering on one side and escaping on the other. It requires about six hours to make one drying at a temperature of 110° to 120° F.

Several films are applied in each drying, and the whole coat is allowed to dry further overnight at room temperature, to be removed on the following morning, when it is graded and packed for market.

From a sanitary viewpoint this method is highly unsatisfactory on account of the accumulation of egg material in the cracks or crevices of the boards and trays, which are not washed, but simply "cleaned" by scraping off the residual matter.

GENERAL SANITARY PRECAUTIONS.

FACTORY LOCATION AND CONSTRUCTION.

A food factory should be designed and located in accord with the general requirements of modern sanitary science, and egg-breaking establishments should, of course, represent the same sanitary conditions as any other food factory. With respect to location, it is highly desirable for food factories to be erected remote from probable sources of contamination and on sandy soil or where drainage is satisfactory. The air of open fields and water fronts, surrounded by growing vegetation, usually contains fewer bacteria per given volume and is of a less objectionable character than that of crowded cities.

Every place in which foods are manufactured or prepared should be located above the ground. The average cellar is absolutely unfit for such purposes, because of inadequate lighting, improper ventilation, accumulation of heavy and noxious gases, dampness, prevalence of rodents, and the general depressing effect on the working force, which is conducive to insanitary practices and indifferent work.

The present-day factory is constructed of fireproof material, as stone, brick, cement, tile, steel, and glass, which are less destructible than wood, and are also more easily kept in a sanitary condition.

All factories should be provided with abundant light, fire escapes, a wholesome water supply, and the necessary toilet facilities for the comfort and cleanliness of the employees. The proper amount of air space should be insured the individual worker.

It is even more essential that the walls and ceiling of workrooms in which food materials are exposed be constructed of hard impervious substances than that the floors should be of such material, although the latter should be made of concrete or some similar material. Rough joists and overhead beams are admirably adapted for the collection of dust and cobwebs, small particles of which are constantly falling on unprotected food materials or into uncovered vessels.

It is absolutely necessary for every food factory to be properly protected from flies, and the clothing worn by the employees should be clean, preferably white, and laundered daily. Particular attention should be called to the condition of the hands of those handling unprotected food materials. Systematic medical inspection of employees and instruction as to the care of the body would be a step toward producing more cleanly food.

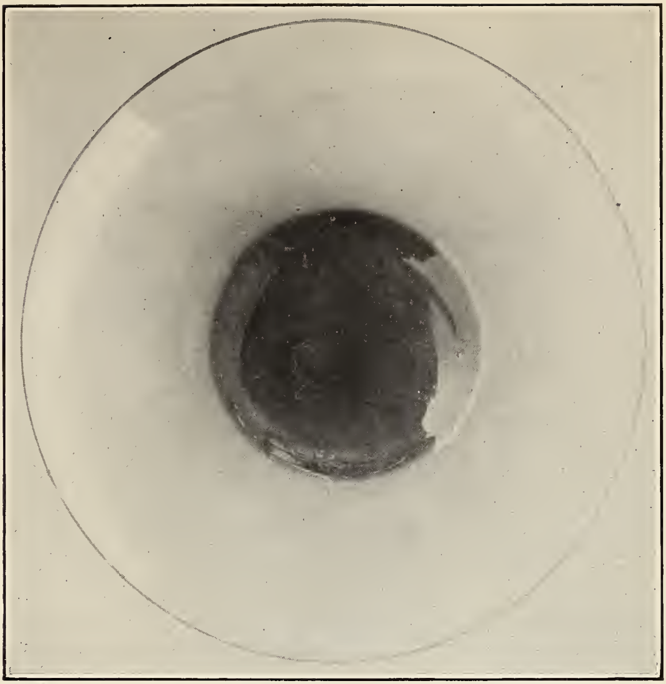


FIG. 1.—A GOOD STORAGE EGG, SHOWING WHOLE YOLK SURROUNDED BY TRANSPARENT WHITE.

FIG. 2.—WEAK EGG, SHOWING THE FLOWING YOLK.

FIG. 1.—ROTTEN EGG, SHOWING DISINTEGRATION OF YOLK.

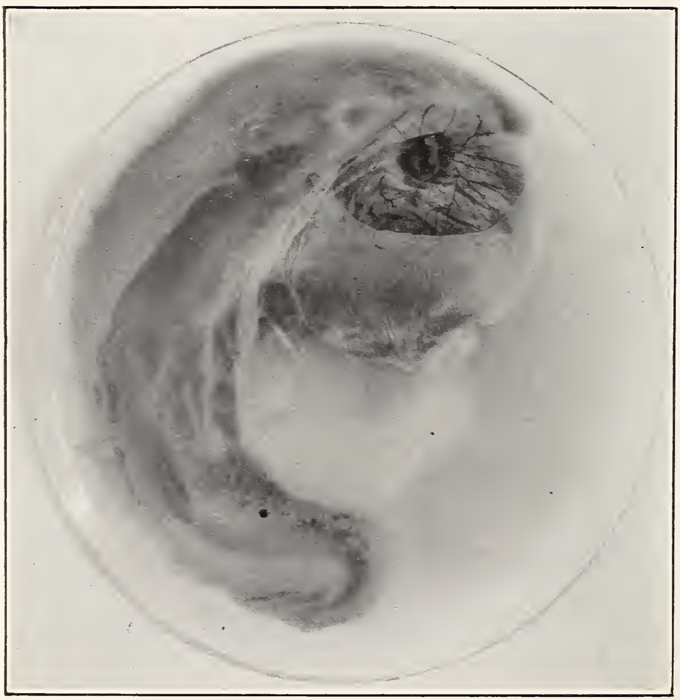
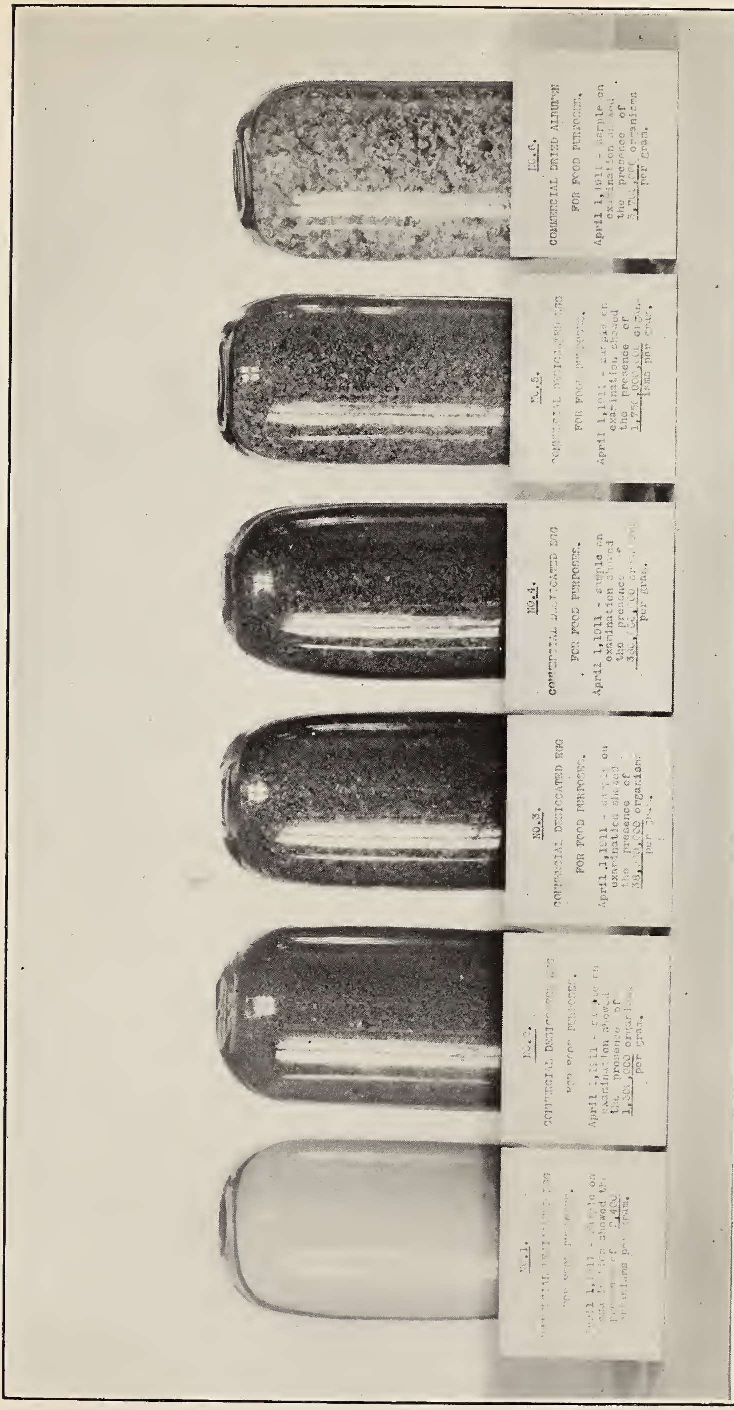


FIG. 2.—SPOT EGG, SHOWING THE DEVELOPMENT OF AN EMBRYO CHICK.



DESICCATED EGG PRODUCTS.

(No. 1. Powdered egg; Nos. 2-5. Flake egg, difficult to distinguish between these four samples by their physical appearance; No. 6. Dried imported egg albumen.)

AIR FILTRATION FOR DESICCATION.

A great deal of difficulty in handling perishable foods arises from contamination by impure air. This is particularly true of factories located in densely populated places where the air is usually heavily laden with dust. The results obtained by exposing agar Petri plates to the air before and after the passage of the ordinary city street sweeper emphasize this point.

Air may be cleansed by heating at temperatures sufficiently high to kill the bacteria present, or it may be filtered through screens made by using thin layers of absorbent cotton arranged in series or be passed through water or over greased slabs. Less difficulty would, of course, be experienced in obtaining air free from bacteria when conditions for contamination were less favorable. The only way, however, to insure the proper protection of foods against air contamination is by using an efficient means of removing the bacteria. It is not so much the mere presence of dust in our foods that is so dangerous as it is bacteria associated with it.

CLEANSING AND STERILIZING UTENSILS.

The modern food factory should not only be properly constructed, but it should also be fully equipped with the necessary facilities for keeping the building, its utensils, and the product clean. Every factory should install the necessary appliances to sterilize all containers and pieces of apparatus used during the handling and preparation of foods, particularly those which come into direct contact with the material during the process of manufacture.

Sterilization may be accomplished by the use of live steam under pressure or by boiling water. The momentary exposure of utensils to live steam as ordinarily practiced is insufficient; a much longer time should be allowed if this method is used. The most satisfactory plan is to pass live steam into a strong cabinet under 15 pounds pressure for about 15 minutes, at the end of which time bacterial life would ordinarily be destroyed. Such a cabinet may be constructed of metal or possibly of reenforced concrete. When hot water is used for cleansing purposes it should be kept boiling, and the containers should receive more than a brief immersion.

After sterilization all containers and materials should be adequately protected from subsequent contamination while not in actual use. The good effects of properly leaning vessels are often nullified by exposing them to dust when they might have been kept clean by simply inverting them.

METHODS USED IN THE BACTERIOLOGICAL EXAMINATION OF EGGS.

STERILIZATION.

All glassware and utensils should be thoroughly cleansed and sterilized before use. Sterilization may be accomplished by the use of dry heat or live steam. An exposure to dry heat at 160° C. for one hour, or until the cotton plugs become slightly brown, is deemed sufficient. Live steam under 15 pounds pressure for 30 minutes usually destroys all organisms.

CULTURE MEDIA.

All culture media are prepared according to the approved methods recommended by the American Public Health Association.[1] Special media not mentioned by this association should be described in detail.

SAMPLING.

In removing samples from the original containers proper care should be exercised to prevent extraneous contamination. Only sterile instruments and containers should be used for this purpose. Representative portions should be removed from solid substances and liquid samples should be well shaken before sampling. Eggs should be examined at once when this is practicable, or be properly iced if in the shell, or frozen if out of it, to prevent bacterial increase until such examinations are made.

RECORDS.

The proper records and means of identification must be observed with each sample.

TECHNIQUE OF EXAMINATION.

Solid substances should be examined on the gram basis; liquid substances on the cubic centimeter basis. Dilutions of solid substances are made by weighing definite quantities of the sample (about 5 grams) in sterile glass-stoppered flasks. To the weighed amount 9 times the quantity of sterile water is added to the sample to make a dilution of 1 to 10. The addition of sterile glass beads to the flask before agitation facilitates the disintegration of solid substances.

[1] Report of the Committee on Standard Methods of Water Analysis to the Laboratory Section of the American Public Health Association; presented at the Havana meeting, January 9, 1905, reprinted from the Journal of Infectious Diseases, May, 1905, Supplement No. 1; also Progress Report of the Committee on Standard Methods for Bacterial Examination of Water and Sewage, reprinted from the Amer. J. Public Hygiene, 1908, vol. 18, No. 4; also Second Progress Report of the Committee on Standard Methods for the Bacterial Examination of Water and Sewage, reprinted from the Amer. J. Public Hygiene, August, 1910, vol. 20, No. 3. The last report of this committee under date of December 19, 1910, has been issued for consideration, but has not been finally approved.

Dilutions of 1 to 100, 1 to 1,000, 1 to 10,000, and any desired number with multiples of 10 may be made by placing 1 cc of the next lower dilution in another flask containing 9 cc of sterile water and shaking each dilution at least 25 times to insure an even mixture. Liquid substances are diluted in the same manner as solid samples after making the first dilution of 1 to 10.

PLATING CULTURES.

At least four dilutions should be made from each sample for every kind of media employed. The strength of the dilutions will necessarily vary according to the experience and material examined. The following dilutions are given as examples:

	Dilution.
Water:	
Unpolluted	1 to $\frac{1}{1,000}$
Polluted	$\frac{1}{10}$ to $\frac{1}{10,000}$
Milk:	
Certified	$\frac{1}{10}$ to $\frac{1}{10,000}$
Market	$\frac{1}{1,000}$ to $\frac{1}{1,000,000}$
Eggs:	
Fresh in shell	1 to $\frac{1}{100}$
Frozen in bulk	$\frac{1}{10,000}$ to $\frac{1}{10,000,000}$
Desiccated	$\frac{1}{10,000}$ to $\frac{1}{10,000,000}$
Oysters:	
In shell (individual)	1 to $\frac{1}{100}$
In shell (composite)	$\frac{1}{10}$ to $\frac{1}{10,000}$
Shucked	$\frac{1}{1,000}$ to $\frac{1}{1,000,000}$

Petri plates are prepared by placing 1 cc of each dilution desired in a corresponding number of sterile plates. Liquefied culture media kept at about 43° C. are then added to each plate containing a dilution, the whole mixture being gently rotated and shaken in such a manner as to produce an even distribution of the organisms present. Plates thus prepared should be solidified at once.

FERMENTATION TESTS.

One cubic centimeter quantities from at least four dilutions, preferably more, should be placed in suitable tubes containing fermentable substances. The ordinary Smith fermentation tube or inverted tubes within larger ones may be used for this purpose. The medium employed may be sterilized ox bile containing 1 per cent of peptone and 1 per cent of lactose, or plain bouillon, to which 1 per cent of dextrose or other sugar has been added.

ANAEROBIC CULTURES.

Anaerobic organisms may be grown in Smith fermentation tubes; shake dextrose in vacuum or under conditions whereby free oxygen has been removed or replaced with hydrogen or some other gas suitable for the growth of such bacteria.

INCUBATION.

Plate cultures should be incubated for from 3 to 5 days, according to the temperature and media employed. Materials containing antiseptics may require a longer time to permit colonies to develop than do those not containing such substances.

Duplicate plain agar plates should be made, one set being incubated at 37° C., or body temperature; the other set at room temperature, or about 20° C. Gelatin plates are incubated at 20° C. and observed daily for the presence of liquefiers.

COUNTING COLONIES.

At the end of the necessary incubation period the colonies should be counted, if necessary, by the use of a low-power lens and ruled plate or by the naked eye when such colonies are well isolated and fully developed. Plates containing about 50 colonies should be selected for this purpose if possible. The number of colonies on a given plate should be multiplied by the dilution used in making such plates in order to determine the total number of bacteria originally present in the material examined.

B. COLI DETERMINATIONS.

From the fermentation tubes showing gas in the two highest dilutions, plate cultures are made on a special differential medium to distinguish between acid and alkaline colonies and to separate the gas-producing types of organisms. When obtained in pure culture the necessary study is made by inoculating such organisms into various media to determine their exact character. The same detailed method should be employed in the study of any organism under consideration.

STREPTOCOCCI DETERMINATIONS.

The presence of *streptococci* may be determined by staining smear preparations from each dilution of the bile cultures and examining them under the microscope for spherical organisms, arranged in typical chain formation.

OTHER ORGANISMS.

The nature of other organisms found in various food materials are considered in relation to the *B. coli* and *streptococci*.

The use of laboratory animals, such as white mice, guinea pigs, rabbits, etc., for experimental purposes in relation to infected and decomposed substances is highly desirable in many instances. The original material itself, or cultures and extracts made therefrom, may be used for this purpose. Such animals may be either fed with the

infected material or injected according to various methods. Only normal, healthy animals should be used, and they should be properly identified, weighed, and careful notes made as to their behavior subsequent to inoculation.

BACTERIOLOGICAL DATA ON FRESH EGGS.

PROCEDURE.

The strictly fresh eggs examined were of a known origin, no egg being more than one day old; they were laid under good conditions and handled in a cleanly manner. The shells were broken on the edge of a sterile Petri dish, and in a number of instances the whites were separated from the yolks at the time of breaking by pouring the egg from one half of the shell to the other, in the same manner as would the housewife, each portion being placed in sterile dishes for analysis. No unusual precautions were observed in breaking the eggs,[1] other than the use of sterile containers for the reception of samples. In removing portions of the egg substance for examination only large-caliber pipettes were used to make dilutions, as great difficulty was experienced in attempting to use the ordinary pipette with small openings. One cubic centimeter quantities were used for analysis instead of weighing 1 gram of the substance, that the results might be expressed on the whole cubic centimeter basis, instead of beginning with 0.1 gram of the material. The eggs having no bacteria in 1 cc of the egg substance examined are considered bacteriologically sterile. The absence or presence of strictly anaerobic organisms was determined by dextrose shake agar cultures.

For the determination of *B. coli* the lactose-peptone-ox-bile medium was used, and the bacterial count was made after three to four days incubation on plain agar, according to the previously outlined methods of examination.

DETAILED DATA OBTAINED.

It will be seen by studying Table 1 that the egg albumen from these strictly fresh eggs contained fewer bacteria than did an equal volume of the egg yolk; and that more of the albumen samples were sterile than were the corresponding samples of yolks separated from the same eggs. Similar results were obtained on the few samples of fresh egg yolks and whites reported in Bulletin 115, Bureau of Chemistry.[2] In her study on fresh eggs of a known grade M. E. Pennington [3] has shown that such eggs contain few if any bacteria, and *B. coli* was not found in the 57 experiments made, including approximately 150 eggs.

---

[1] U. S. Dept. Agr. Bureau of Chemistry Bul. 115. Effect of Cold Storage on Eggs, Quail, and Chickens, by Wiley, Pennington, Stiles, Howard, and Cook.

[2] Loc. cit.

[3] A chemical and bacteriological study of fresh eggs J. Biol. Chem., 1910, 7 (2): 109.

TABLE 1.—*Strictly fresh shell eggs April to October, 1911.*

Number of organisms per cubic centimeter, and month.	Number of samples of—		Percentage of samples of—	
	Yolk.	Albumen.	Yolk.	Albumen.
April, 1911:				
0	37	58	39.78	62.36
1–10	44	27	47.31	29.03
10–25	6	4	6.45	4.30
25–50	2	3	2.15	3.22
50–100	2	0	2.15	.00
100–250	2	1	2.15	1.07
250–500	0	0	.00	.00
500–higher	0	0	.00	.00
May, 1911:				
0	5	16	14.28	45.71
1–10	9	13	25.71	37.14
10–25	5	3	14.28	8.57
25–50	5	1	14.28	2.85
50–100	2	1	5.71	2.85
100–250	3	1	8.57	2.85
250–500	0	0	.00	.00
500–higher	6	0	17.14	.00
June, 1911:				
0	5	25	6.25	30.12
1–10	16	45	20.00	54.21
10–25	23	8	28.75	9.63
25–50	14	4	17.50	4.82
50–100	14	0	17.50	.00
100–250	2	1	2.50	1.20
250–500	2	0	2.50	.00
500–higher	4	0	5.00	.00
July, 1911:				
0	9	38	6.52	27.53
1–10	24	60	17.39	43.47
10–25	24	20	17.39	14.49
25–50	17	11	12.32	7.97
50–100	26	3	18.84	2.17
100–250	15	1	10.87	.72
250–500	8	2	5.79	1.44
500–higher	15	3	10.87	2.17
August, 1911:				
0	7	20	5.65	16.12
1–10	22	67	17.74	54.04
10–25	3	10	2.42	8.07
25–50	10	12	8.07	9.67
50–100	16	10	12.90	8.07
100–250	31	5	25.00	4.03
250–500	17	0	13.71	.00
500–higher	18	0	14.51	.00
September, 1911:				
0	5	8	16.66	26.66
1–10	3	18	10.00	60.00
10–25	5	4	16.66	13.33
25–50	8	0	26.66	.00
50–100	3	0	10.00	.00
100–250	3	0	10.00	.00
250–500	2	0	6.66	.00
500–higher	1	0	3.33	.00
October, 1911:				
0	10	19	8.85	16.81
1–10	15	75	13.28	66.39
10–25	19	10	16.81	8.85
25–50	16	4	14.16	3.53
50–100	19	4	16.81	3.53
100–250	18	1	15.95	.88
250–500	6	0	5.31	.00
500–higher	10	0	8.85	.00

TABLE 1.—*Strictly fresh shell eggs April to October, 1911*—Continued.

SUMMARY OF RESULTS.

Month.	Number of samples.	Minimum count.		Maximum count.		Average count.		Percentage of sterile samples.	
		Yolk.	Albumen.	Yolk.	Albumen.	Yolk.	Albumen.	Yolk.	Albumen.
April	93	0	0	180	140	6.2	3.6	39.78	62.36
May	35	0	0	2,750	120	318.6	10.1	14.28	45.71
June	[1] 83	0	0	17,500	220	335.1	6.74	6.25	30.12
July	138	0	0	[2] 18,000	900	473.2	36.5	6.52	27.53
August	124	0	0	9,300	200	344.2	18.9	5.65	16.12
September	30	0	0	1,400	20	99.66	3.6	16.66	26.66
October	113	0	0	6,000	328	240.2	9.3	8.85	16.81
Total and average	616					271.7	15.9		

[1] Three samples of yolk were broken.
[2] This is the individual yoke containing *B. coli.*

The following temperature record is of interest in connection with the data obtained on the fresh eggs.

TABLE 2.—*Temperature record for the months of April to October, 1911, at Washington, D. C.*

Month.	Temperatures.		
	Average.	Maximum.	Minimum.
1911.	° *F.*	° *F.*	° *F.*
April	51.2	80	26
May	70.0	96	37
June	73.0	101	56
July	78.7	99	56
August	76.6	100	54
September	70.4	89	46
October	57.2	80	38

TABLE 3.—*Commercial fresh whole eggs,*[1] *Apr. 29. 1908, to Oct. 10, 1912.*

Organisms per cubic centimeter.	Number of samples.	Percentage.
0	11	20.7
1–10	11	20.7
10–25	6	11.3
25–50	8	15.1
50–100	3	5.6
100–250	0	.0
250–500	1	1.9
500–higher	13	24.5

Maximum bacteria per cubic centimeter	20,000
Average bacteria per cubic centimeter	1,026
Number of eggs examined	53

[1] Eggs from miscellaneous sources sold as fresh eggs.

SUMMARY OF RESULTS ON FRESH EGGS.

There were no *B. coli* present in 1 cc quantities of the 616 samples of albumen examined between April and October, 1911; and of the 613 [1] yolk determinations on the same eggs, *B. coli* were found in only one instance and this occurred during the month of July.

The summary of Table 1, given on page 23, shows the following results:

The average bacterial content for the whole seven months was 15.9 per cubic centimeter for the albumen samples and for the yolk samples 271.7 organisms per cubic centimeter. The minimum monthly average of the bacterial content for the albumen samples is found in April and September, amounting to 3.6, while the maximum was 36.5 in July. The minimum monthly average for the yolk samples occurs also in April, amounting to 6.2, and the maximum is again found in July, the figure being 473.2.

The largest number of sterile yolks is recorded in April (39.78 per cent), all other monthly averages being much lower, September standing second with only 16.66 per cent and May third with 14.28 per cent. Considering the albumen samples, April again stands first with 62.36 per cent of sterile samples, May following with 45.71 and June with 30.12.

The commercial fresh eggs were obtained from miscellaneous sources, exact age unknown; of the 53 whole eggs examined 20.7 per cent were sterile in 1 cc quantities, the maximum count was 20,000 organisms, and the average 1,026 per cubic centimeter, with no *B. coli* present.

EXPERIMENTS WITH FROZEN EGG PRODUCTS.

PREPARATION OF SAMPLES.

A number of laboratory experiments on the various grades of frozen egg products have been made, and the results obtained are given in Tables 4 to 13. The eggs had been candled in a commercial house and were recandled in the laboratory in all cases. The material was prepared by breaking several dozen shell eggs in a uniform manner by opening over a cup, after which they were placed in other containers according to grade. From each grade thus prepared portions of approximately 50 cc quantities were introduced, after thorough mixing, into sterilized, cotton-stoppered, Erlenmeyer flasks and held at about 10° F. The thermograph readings varied but slightly from this figure during the investigation. At frequent intervals one of the flasks was removed from storage, and after quickly melting the contents the analysis was made in the usual manner. Table 15 gives the results obtained on 312 samples of commercial frozen eggs analyzed when purchased on the market, during a period of seven months, from September 28 to May 1, inclusive.

[1] Three samples of yolk were broken.

BACTERIOLOGICAL DATA.

TABLE 4.—*Strictly fresh whole eggs, frozen and examined at intervals from Feb. 14, 1910, to Mar. 29, 1911.*

(Six dozen eggs used, none over 4 days old. *B. coli* not present in 1 cc quantities.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2167	300	300	0	0
2176	400	400	0	1
2213	1,200	1,400	....	5
2234	1,000	1,000	....	11
2250	900	700	....	19
2299	1,000	800	....	30
2308	500	400	0	37
2376	800	800	....	45
2396	600	600	....	50
2429	1,400	1,300	....	56
2435	1,600	1,200	....	63
2455	1,000	900	0	71
2556	900	900	....	80
2583	1,400	700	0	87
2592	1,200	1,200	....	92
2621	1,700	2,000	....	100
2643	200	100	....	109
2659	300	300	....	115
2769	600	400	0	185
2826	100	100	....	197
2906	600	200	....	210
2931	80	50	....	219
2962	700	700	....	253
3038	300	400	....	276
3112	400	200	0	286
3215	100	100	....	323
3366	200	200	0	407

Maximum average count 1,850
Minimum average count 65

TABLE 5.—*Frozen albumen from strictly fresh eggs, examined at intervals from Feb. 15, 1910, to Mar. 29, 1911.*

(Four dozen eggs, none over 4 days old.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2168	0	0	0	0
2177	20	10	....	1
2214	100	100	....	4
2251	200	100	....	14
2300	300	200	0	29
2308	400	400	....	36
2377	160	150	....	44
2397	200	100	....	49
2557	600	600	....	79
2622	500	500	....	99
2644	100	100	....	106
2770	200	100	0	182
2826	100	100	....	194
2907	100	100	....	206
2932	70	90	....	216
2963	180	100	....	240
3040	200	100	....	262
3113	60	60	0	272
3224	100	100	....	323
3373	8	7	....	410

Maximum average count 600
Minimum average count 0
B. coli not present in 1 cc quantities.

TABLE 6.—*Frozen albumen from commercial eggs, examined at intervals from Feb. 16, 1910, to Mar. 29, 1911.*

(Four dozen eggs bought on the market as fresh.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2189	60	40	0	0
2253	400	300	....	14
2302	700	500	0	29
2311	600	500	....	36
2379	700	500	....	44
2772	400	200	0	182
2827	100	100	....	194
2934	300	300	0	216
2965	100	100	....	240
3037	100	100	....	262
3115	180	100	0	272
3225	100	100	....	323
3374	20	10	....	410

Maximum average count........ 600
Minimum average count........ 15
B. coli not present in 1 cc quantities.

TABLE 7.—*Commercial whole eggs, frozen and examined at intervals from Feb. 16, 1910, to Mar. 29, 1911.*

(Eight dozen eggs said to have been in cold storage for 8 months.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2188	800	700	(1)	0
2215	900	900	....	3
2252	1,400	1,000	....	14
2301	3,600	2,700	0	29
2311	600	500	....	36
2378	1,200	1,000	....	44
2398	2,500	1,300	....	49
2431	4,400	3,000	....	55
2436	2,700	2,400	....	62
2457	2,800	1,000	(1)	70
2558	12,000	7,000	....	79
2585	1,500	1,400	....	86
2593	2,200	2,000	....	91
2623	3,000	1,000	....	99
2645	7,000	7,000	....	106
2661	2,000	2,000	....	112
2771	900	800	(1)	182
2831	1,400	400	....	194
2908	500	300	....	206
2933	200	100	....	216
2964	800	800	....	240
3036	100	....	....	262
3114	800	400	(1)	272
3223	900	1,100	....	321
3367	900	800	....	406

[1] *B. coli* absent in 0.1 cc.

Maximum average count........ 9,500
Minimum average count........ 100

TABLE 8.—*Eggs called checks and cracks frozen and examined at intervals from May 12, 1910, to Mar. 29, 1911.*

(Six dozen eggs as received by a commercial egg house among current receipts.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2578	17,000	13,000	1	0
2626	200,000	20,000	....	13
2663	140,000	120,000	....	27
2777	7,000	4,000	(1)	96
2833	30,000	40,000	....	108
2935	90,000	60,000	....	120
2966	34,000	31,000	....	164
3043	70,000	22,000	....	186
3116	30,000	21,000	(1)	196
3220	10,000	4,000	....	262
3369	16,000	15,000	....	317

[1] *B. coli* not present in 0.1 cc.

Maximum average count 130,000
Minimum average count 5,500

TABLE 9.—*Eggs called "dirties" frozen and examined at intervals from May 12, 1910, to Mar. 29, 1911.*

(Six dozen eggs as received in current receipts by commercial trade.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2579	200,000	140,000	(1)	0
2627	170,000	100,000	....	13
2664	320,000	....	....	27
2778	80,000	20,000	(2)	96
2834	100,000	3,200	....	108
2912	160,000	80,000	....	120
2936	90,000	30,000	....	130
2967	100,000	40,000	....	164
3042	18,000	....	....	186
3221	57,000	14,000	....	262
3370	50,000	40,000	....	317

[1] *B. coli* not present in 0.1 cc. [2] *B. coli* not present in 0.01 cc.

Maximum average count 320,000
Minimum average count 18,000

TABLE 10.—*"Hot weather" eggs*[1] *frozen and examined at intervals from Aug. 18, 1910, to Mar. 29, 1911.*

(Four dozen eggs received by a commercial house from current receipts.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2779	700	200	(2)	0
2913	1,000	1,000	....	25
2937	1,400	1,000	....	36
2968	5,000	5,000	....	68
3039	600	900	....	90
3222	700	1,000	....	137
3368	400	300	....	221

[1] By this commercial term was meant rollers or floaters and eggs with watery albumen.
[2] *B. coli* not present in 0.01 cc.

Maximum average count 5,000
Minimum average count 350

TABLE 11.—*"Light spot" eggs*[1] *frozen and examined at intervals from May 12, 1910, to Jan. 4, 1911.*

(Four dozen eggs received by a commercial firm.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2580	6,700,000	2,000,000	100,000	0
2647	28,000,000	20,000,000	....	22
2774	2,500,000	3,000,000	100,000	98
2835	10,000,000	4,400,000	....	110
2969	8,000,000	6,000,000	....	166
3041	4,300,000	2,900,000	....	189
3216	5,000,000	4,000,000	....	236

[1] In this grade were included all of the eggs that before the candle showed the beginning of spot development which may have been a stuck spot, an embryo spot, blood ring, or a mold spot.

Maximum average count........ 24,000,000
Minimum average count........ 2,750,000

TABLE 12.—*"Heavy spot" eggs*[1] *frozen and examined at intervals from May 12, 1910, to Mar. 29, 1911.*

(Seven dozen eggs received from the trade as discards.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2581	22,000,000	6,000,000	1,000,000	0
2595	90,000,000	40,000,000	....	7
2628	150,000,000	150,000,000	....	13
2648	150,000,000	110,000,000	....	21
2775	80,000,000	50,000,000	1,000,000	96
2832	78,000,000	70,000,000	....	108
2914	90,000,000	70,000,000	....	120
2938	90,000,000	67,000,000	....	130
2970	120,000,000	34,000,000	....	164
3177	180,000,000	100,000,000	....	262
3371	120,000,000	120,000,000	....	317

[1] In this grade is included all eggs showing a marked development of stuck, mold, embryo spots or blood rings.

Maximum average count........ 150,000,000
Minimum average count........ 14,000,000

TABLE 13.—*Eggs called "blood rings"*[1] *frozen and examined at intervals from May 12, 1910, to Jan. 4, 1911.*

(Four dozen eggs received from the trade as discards from candling.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2582	500,000,000	300,000,000	....	0
2649	2,160,000,000	2,000,000,000	....	22
2776	800,000,000	500,000,000	....	96
2829	310,000,000	380,000,000	....	108
2971	800,000,000	800,000,000	....	164
3044	675,000,000	600,000,000	....	180
3219	900,000,000	1,000,000,000	....	262

[1] These eggs showed the development of at least 3-day embryos; in no case were the embryos living; therefore designated as blood rings.

Maximum average count........ 2,080,000,000
Minimum average count........ 350,000,000

TABLE 14.—*"Rotten" eggs*[1] *frozen and examined at intervals from Mar. 16, 1910, to Mar. 29, 1911.*

(Four dozen eggs received by the trade, discards from candling.)

Sample No.	Organisms per cubic centimeter.		*B. coli* per cubic centimeter.	Days in storage.
	At 25° C.	At 37° C.		
2303	720,000,000	1,400,000,000	100,000,000	0
2312	8,000,000,000	3,000,000,000		7
2380	1,200,000,000	1,000,000,000		15
2399	600,000,000	300,000,000		21
2458	900,000,000	300,000,000		46
2559	600,000,000	400,000,000		49
2586	800,000,000	900,000,000		56
2624	700,000,000	600,000,000		69
2646	400,000,000	200,000,000		79
2773	900,000,000	800,000,000		155
2910	500,000,000	300,000,000		176
2972	500,000,000	400,000,000		220
3118	500,000,000	200,000,000	10,000,000	253
3218	600,000,000	300,000,000		291
3372	600,000,000	600,000,000		378

[1] Includes all classes of "rots" except "black rots" not used for tanning.

Maximum average count 5,500,000,000
Minimum average count 300,000,000

TABLE 15.—*Commercial frozen eggs sold as food, Sept. 28, 1909, to May 1, 1911.*

Organisms per cubic centimeter.	Number of samples.	Percentage.
Below 10,000	0	0
10,000–50,000	8	2.5
50,000–100,000	7	2.2
100,000–500,000	30	9.6
500,000–1,000,000	19	6.0
1,000,000–10,000,000	67	21.4
10,000,000–50,000,000	88	28.2
50,000,000–100,000,000	39	12.5
100,000,000–500,000,000	44	14.1
500,000,000–1,000,000,000	6	1.9
Above 1,000,000,000	4	1.2

Minimum number per cc 20,000
Maximum number per cc 1,180,000,000
Average number per cc 89,504,805
Number of samples examined 312

SUMMARY OF RESULTS ON FROZEN EGG PRODUCTS.

The following statement, based on the detailed data herein given, covering single lots of from 4 to 8 dozens of each grade of eggs examined, must be considered as tentative, as the examination of a larger number of samples may modify the final conclusions.

Strictly fresh and commercially fresh frozen eggs held in storage for more than one year showed but little variation in their bacterial content during this period. The grades designated "dirties," "checks," "cracks," and "hot-weather" eggs gave a maximum bacterial count of 320,000 organisms and a minimum of 350 per cubic

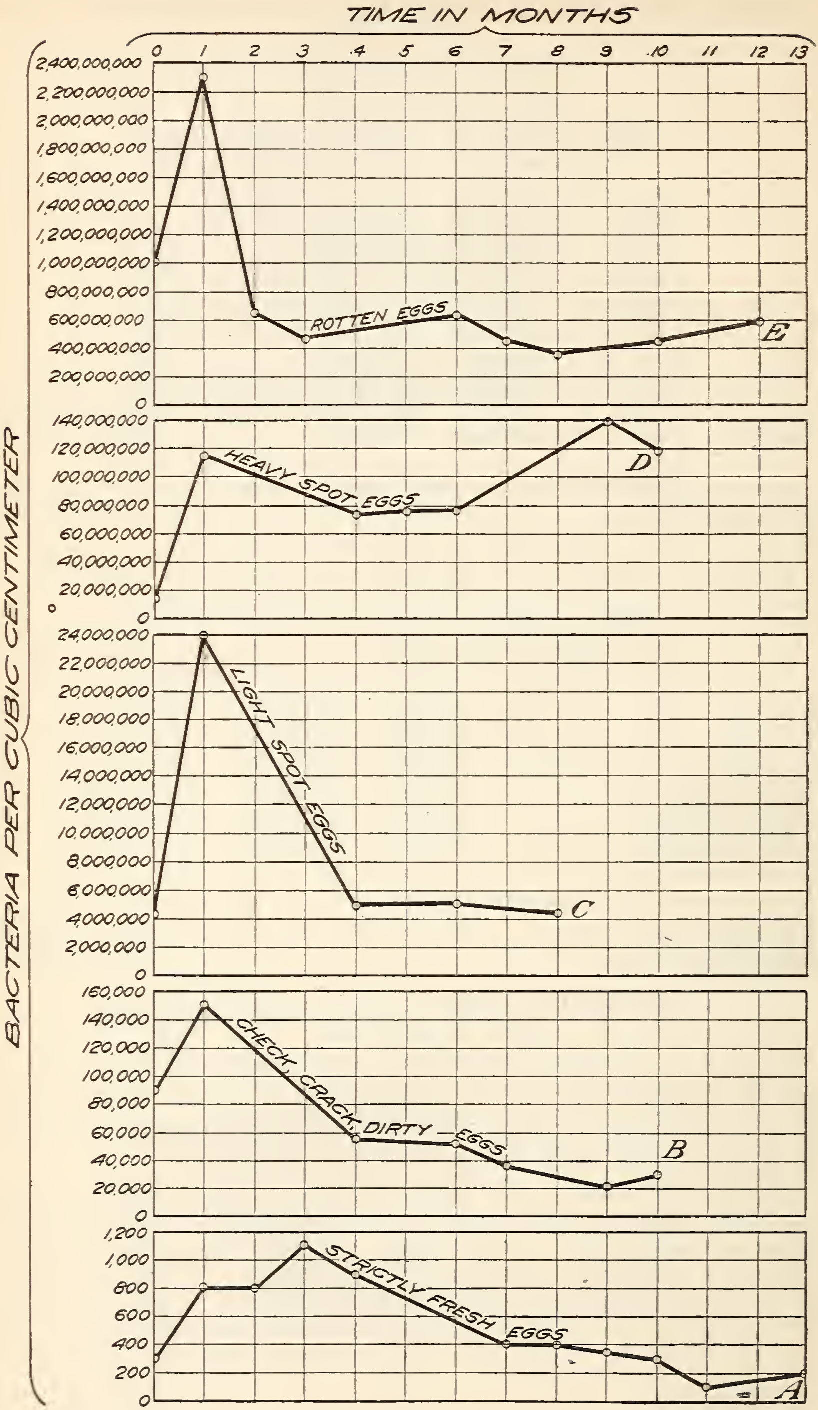


FIG. 1.—Graph showing bacterial content of frozen eggs of known grades, examined at intervals, and averaged by months.

(Plotted data are averages of number of organisms developing at 25° C. and 37° C. in all samples examined during the interval shown: A, compiled from Table 4; B, compiled from Tables 8 and 9; C, compiled from Table 11; D, compiled from Table 12; E, compiled from Table 14.)

centimeter. *B. coli* were absent in the strictly fresh and commercially fresh samples, but were found in 1 cc quantities of the checks and cracks.

Spot eggs, comprising the various grades from "light spots" to "rots," showed bacterial counts ranging from a few million to a billion organisms, with a large proportion of *B. coli.*

In Table 15 it will be observed that 64, or 20.5 per cent, of the 312 samples of commercial frozen eggs, bought on the market as food, contained 1,000,000 or less organisms per cubic centimeter, while 54 samples, or 17.3 per cent, contained 100,000,000 or more per cubic centimeter.

EXPERIMENTS WITH DRIED EGG PRODUCTS.

CONDITIONS OF THE EXPERIMENT.

Experiments on the various grades of dried eggs were conducted in about the same way as with the frozen material. (See p. 24.) About 1 quart of each grade was placed in a sterile screw-cap jar and held at 34° F., samples being removed at different intervals for analysis. Tables 16 and 17 give the results obtained in the laboratory experiments with the strictly fresh and with commercial eggs, while the remaining tables deal with commercially prepared products of several kinds.

In the case of the laboratory experiment on fresh desiccated eggs (see Table 16) 4 dozen strictly fresh eggs of known history were broken and dried under laboratory conditions, observing only the ordinary precautions such as should prevail in a well-equipped egg-breaking establishment. These eggs were broken into a large container and divided into 4 equal parts. Each portion was placed in a sterile covered jar. No. 1 was dried at once. Nos. 2, 3, and 4 were stored at about 34° F., and on each of the three successive days one jar was removed for examination and drying. In each case the eggs were examined before and after drying. The dried eggs were kept at about 34° F. during the entire experiment.

Other additional lots similarly prepared were examined in a similar manner, except that they were held at 34° F. for three successive days in a single container. One of these lots was composed of strictly fresh eggs, while the other was made up of "cracks" and "dirties" taken from near-by current receipts in March. The results obtained from these last two experiments were practically the same as noted in Table 15. *B. coli* were not present in any instance in 1 cc quantities.

BACTERIOLOGICAL DATA.

TABLE 16.—*Strictly fresh desiccated eggs prepared under laboratory conditions and examined from Mar. 25, 1910, to Apr. 7, 1911.*

(Four dozen eggs, known history.)

Sample No. and description.	Organisms per gram.		*B. coli* per gram.	Days in storage.
	At 25° C.	At 37° C.		
Jar No. 1—dried first day:				
2317	400	200	0	(1)
2318	1,500	1,000	0	(2)
2503	2,200	2,200	0	35
3123	2,100	1,900	0	244
3419	1,800	1,800	0	378
Jar No. 2—dried second day:				
2332	300	300	0	(1)
2332-a	1,900	1,000	0	(2)
2504	2,600	2,000	0	34
3124	2,100	2,000	0	243
3420	2,200	1,600	0	377
Jar No. 3—dried third day:				
2351	200	200	0	(1)
2352	1,900	1,200	0	(2)
2505	4,000	3,200	0	33
3125	2,000	1,700	0	242
3421	1,900	1,100	0	376
Jar No. 4—dried fourth day:				
2355	90	70	0	(1)
2356	1,400	1,300	0	(2)
2506	2,000	2,100	0	32
3126	1,900	1,800	0	241
3422	1,500	800	0	375

[1] Liquid stock before drying, results expressed per cubic centimeter.
[2] After desiccation, same day as preceding sample.

TABLE 17.—*Commercial desiccated whole eggs examined Sept. 11, 1909, to Mar. 29, 1911.*

(Commercially prepared with no added yolk; kept at about 34° F. during the experiment; liquid stock was not examined.)

Sample No.	Organisms per gram.		*B. coli* per gram.	Days after receipt.
	At 25° C.	At 37° C.		
1657	1,500,000	410,000	1,000	0
2241	1,000,000	700,000	(1)	170
3138	600,000	500,000	(1)	444
3376	500,000	200,000	(1)	563

[1] *B. coli* not present in 0.001 gram.

TABLE 18.—*Commercial desiccated whole eggs with 20 per cent added yolk, examined Sept. 11, 1909, to Mar. 29, 1911.*

(Commercially prepared; kept at about 34° F. during the experiment; liquid stock not examined.)

Sample No.	Organisms per gram.		*B. coli* per gram.	Days after receipt.
	At 25° C.	At 37° C.		
1659	80,000,000	130,000,000	100,000,000	0
2243	80,000,000	20,000,000	10,000,000	200
3140	32,000,000	32,000,000	1,000,000	443
3378	16,000,000	9,000,000	1,000,000	563

TABLE 19.—*Commercial desiccated yolks with and without sugar, examined Sept. 11, 1909, to Mar. 29, 1911.*

(Commercially prepared; kept at about 34° C. during the experiment; liquid stock was not examined.)

Sample No.	Organisms per gram.		*B. coli* per gram.	Days after receipt.
	At 25° C.	At 37° C.		
No added sugar:				
1656	8,000,000	31,000,000	10,000	0
2240	8,000,000	70,000,000	100,000	200
3137	6,000,000	8,000,000	....	443
3375	3,700,000	2,200,000	1,000	563
10 per cent sugar added before drying:				
1660	17,000,000	19,000,000	100,000	0
2244	11,000,000	9,000,000	100,000	200
3141	2,200,000	2,100,000	....	443
3379	600,000	400,000	(1)	563

[1] *B. coli* not present in 0.001 gram.

The decrease in bacterial content was decidedly more marked in the case of the dried eggs containing sugar.

TABLE 20.—*Commercial desiccated whole eggs for tanning purposes, examined Sept. 11, 1909, to Mar. 29, 1911.*

(Commercially prepared; kept at about 34° F. during the experiment; liquid stock was not examined.)

Sample No.	Organisms per gram.		*B. coli* per gram.	Days after receipt.
	At 25° C.	At 37° C.		
1663	600,000,000	260,000,000	10,000,000	0
2247	400,000,000	160,000,000	10,000,000	200
3144	200,000,000	200,000,000	10,000,000	443
3381	210,000,000	140,000,000	10,000,000	563

TABLE 21.—*Imported dried albumen examined Mar. 4, 1910, to Apr. 25, 1911.*

Organisms per gram.	Number.	Percentage.
Below 50,000	0	0
50,000–100,000	2	2.6
100,000–500,000	3	4.0
500,000–1,000,000	4	5.3
1,000,000–10,000,000	20	26.6
10,000,000–50,000,000	33	44.0
Above 50,000,000	13	17.3

Minimum bacteria per gram	65,000
Maximum bacteria per gram	148,000,000
Average bacteria per gram	13,126,000
Samples examined	75

TABLE 22.—*Commercial desiccated eggs bought on the market as food from Sept. 1, 1909, to May 1, 1911, and examined at the time of purchase.*

Organisms per gram.	Number.	Percentage.
Below 10,000	4	2.1
10,000–50,000	1	.5
50,000–100,000	1	.5
100,000–500,000	5	2.6
500,000–1,000,000	2	1.0
1,000,000–10,000,000	19	10.0
10,000,000–50,000,000	36	18.9
50,000,000–100,000,000	23	12.1
100,000,000–500,000,000	60	31.5
500,000,000–1,000,000,000	24	12.6
Above 1,000,000,000	15	7.9

Minimum number per gram	2,200
Maximum number per gram	2,100,000,000
Average number per gram	304,062,777
Number of samples examined	190

SUMMARY OF RESULTS ON DRIED EGG PRODUCTS.

The results of the bacteriological examination of 75 samples of dried imported egg albumen in Table 21 showed that 9 out of 75 samples, or 12 per cent, contained 1,000,000 organisms or less per gram; while 46 samples, or 61.3 per cent, showed 10,000,000 or more bacteria per gram.

Considering Table 22 on commercial desiccated eggs, it will be seen that 13 of the 190 samples examined, or 6.8 per cent, showed 1,000,000 or less organisms per gram; while 99 of the 190 samples, or 52 per cent, contained 100,000,000 or more bacteria per gram. These results show that more than one-half of the samples of the commercial dried egg products examined, which had entered interstate commerce for food purposes, corresponded bacteriologically to the grade of eggs designated "heavy spots" and "rots." It can not be concluded from this, however, that such eggs were used in these products, as investigations now making by this bureau show that the ordinary handling of the product may introduce as many bacteria as though some rots and spots were actually included.

GENERAL CONCLUSIONS.

(1) Under normal conditions, strictly fresh eggs contain few if any bacteria, and no appreciable numbers of *B. coli* in 1 cc quantities.

(2) Frozen egg products prepared in the laboratory in Washington from second-grade eggs comprising "undersized," "cracks," "dirties," and "weak eggs" generally show a total bacterial content of less than 1,000,000 organisms per gram, while dried eggs prepared from the same grades usually contain a total bacterial content of less than 4,000,000 organisms per gram, both kinds containing but a very small number of *B. coli;* from a bacteriological standpoint they are considered an edible product.

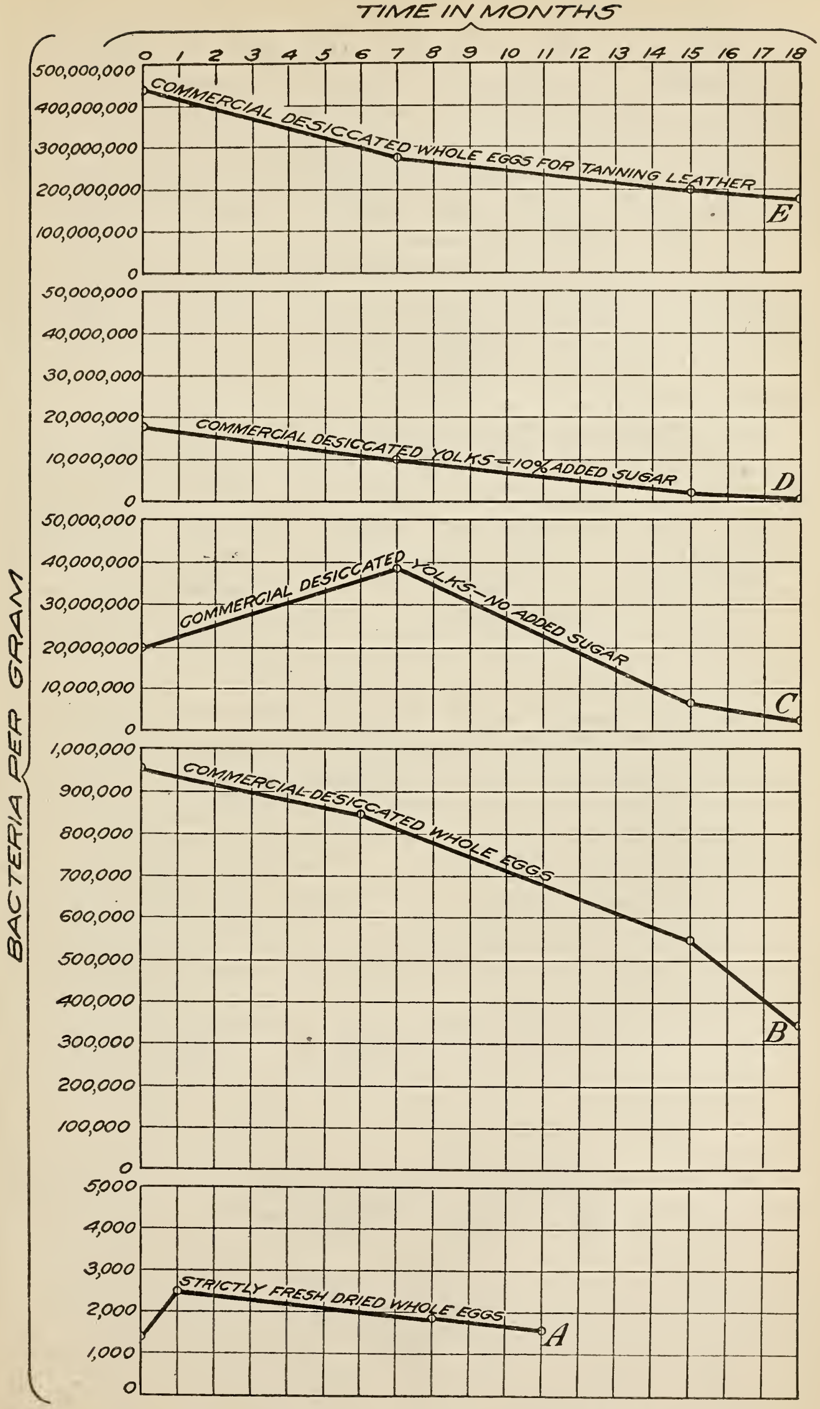


FIG. 2.—Graph showing bacterial content of desiccated eggs of known grades, examined at intervals and averaged by months.

(Plotted data are averages of number of organisms developing at 25° C. and 37° C. in all samples examined during the interval shown: A, compiled from Table 16; B, compiled from Table 17; C and D, compiled from Table 19; E, compiled from Table 20.)

(3) Frozen products made from "light spots," "heavy spots," "blood rings," and "rots"[1] show bacterial counts generally ranging from about 1,000,000 to 1,000,000,000, while dried eggs made from the same grades usually contain from 4,000,000 to more than 1,000,000,000 organisms per gram with a relatively high proportion of *B. coli* and *streptococci* in both the frozen and dried material, indicating an unwholesome article, unfit for food, and only useful for tanning leathers, or for other technical purposes.

(4) While the principle of preserving food by the abstraction of moisture and refrigeration is recognized as a perfectly legitimate business when applied to wholesome products, no amount of freezing and desiccation will rejuvenate eggs already decomposed in whole or in part.

(5) The experiments herein reported on frozen and dried egg products kept at low temperatures indicate during the early part of storage a general rise in the bacterial content with a subsequent decline in numbers. This decline was more marked in the case of dried eggs containing 10 per cent added sugar than in similar products to which no sugar was added, indicating that the sugar has acted as an antiseptic, as might be expected; such an addition might, therefore, be employed to conceal inferiority. This point, however, must receive further study before it can be safely discussed.

(6) The egg industry in this country constitutes so valuable a source of food that it is very essential that undesirable practices attending any branch of it be remedied as quickly as possible. Increased care in the production and handling of this highly perishable article on the part of both the producer and the buyer will, to a large extent, bring about these desired conditions. Already the Federal Government and a number of States through their boards of health and experiment stations are doing effective work toward raising the quality of market eggs, and at the same time decreasing losses due to careless or delayed handling.

[1] See p. 12 for exact definition of these terms as here used.

ADDITIONAL COPIES of this publication may be procured from the SUPERINTENDENT OF DOCUMENTS, Government Printing Office, Washington, D. C., at 10 cents per copy